

**UNIVERSITI TEKNOLOGI MARA**

**BIODEGRADATION OF  
MICROPLASTIC IN  
MICROALGAE-BASED  
MICROBIAL FUEL CELLS  
(MFC)**

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## ABSTRACT

Microplastic pollution poses a growing threat to aquatic ecosystems due to its persistence and capacity to accumulate hazardous substances. This study aims to investigate the potential of the marine microalga *Chlorella vulgaris* integrated within a Microbial Fuel Cell (MFC) system as a biological approach for simultaneous microplastic degradation and bioelectricity generation. *Chlorella vulgaris* was selected for its adaptability, efficient nutrient uptake, and bioenergy potential. Response Surface Methodology (RSM) was used to optimize growth parameters in wastewater, achieving a biomass yield closely matching predicted values under optimal conditions (pH 7, BBM ratio 0.49). These optimized conditions were applied in an MFC system where four types of microplastics (PE, PP, PS, and PET) were introduced to evaluate their influence on algal growth, microplastic degradation, and voltage generation. Among the microplastics tested in the microalga based microbial fuel cell, PE supported the highest specific growth rate of *C.vulgaris* ( $0.1628 \text{ day}^{-1}$ ), while PP resulted in the highest biomass of *C.vulgaris* production (0.8600 g/L). The system also generated bioelectricity, with the highest voltage output (0.08 V) observed in the presence of PE, indicating enhanced electrochemical activity. Although limited by a 21-day experimental period and the exclusion of additive effects in commercial plastics, the findings highlight the potential of microalgae-based MFCs as a sustainable solution for simultaneous wastewater treatment, microplastic degradation, and renewable energy generation. This study offers valuable insights toward the development of environmentally friendly technologies in alignment with global sustainability goals.

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# CHAPTER 1

## INTRODUCTION

### 1.1 Research Background

Plastic pollution has emerged as a pressing global environmental issue, largely due to the persistent and pervasive nature of microplastics—tiny plastic particles measuring less than 5 mm in diameter (Bessa et al., 2018). These microplastics are primarily generated from the degradation of larger plastic waste through mechanical processes such as abrasion, as well as photochemical oxidation caused by exposure to sunlight. Among the most found plastic polymers in aquatic environments are polyethylene (PE), polypropylene (PP), and polyethylene terephthalate (PET), which are favored in various industries for their low cost, chemical stability, and versatile functionality. However, their widespread use and resistance to natural degradation have led to significant accumulation in marine and freshwater systems, including oceans, rivers, lakes, and coastal regions, thereby posing serious ecological threats (Auta et al., 2017). These microplastics not only disrupt the natural habitats of marine organisms but also interfere with critical ecosystem functions.

A particularly alarming aspect of microplastic pollution is their ability to act as vectors for hazardous chemical substances. Microplastics can absorb and concentrate environmental pollutants such as heavy metals, persistent organic pollutants (POPs), and other toxic additives that are either originally incorporated into plastic products or present in the surrounding environment (Moog et al., 2019). Once these contaminated particles are ingested by aquatic organisms, they can lead to internal toxicities, behavioral changes, and reduced reproductive success. Furthermore, the pollutants may bioaccumulate and biomagnify as they ascend through the food chain, potentially affecting higher trophic level organisms, including humans (Qu et al., 2018). This bioaccumulation presents a serious concern for the integrity and health of entire ecosystems.

Recent research efforts have begun to investigate the potential role of microalgae in mitigating microplastic pollution through biological degradation. Certain microalgal species, particularly *C. vulgaris*, have shown promise in adhering to plastic surfaces, forming dense biofilms, and secreting extracellular polymeric substances